Consolidated Design Report

VVC Throwing and Hockey Shooting Area

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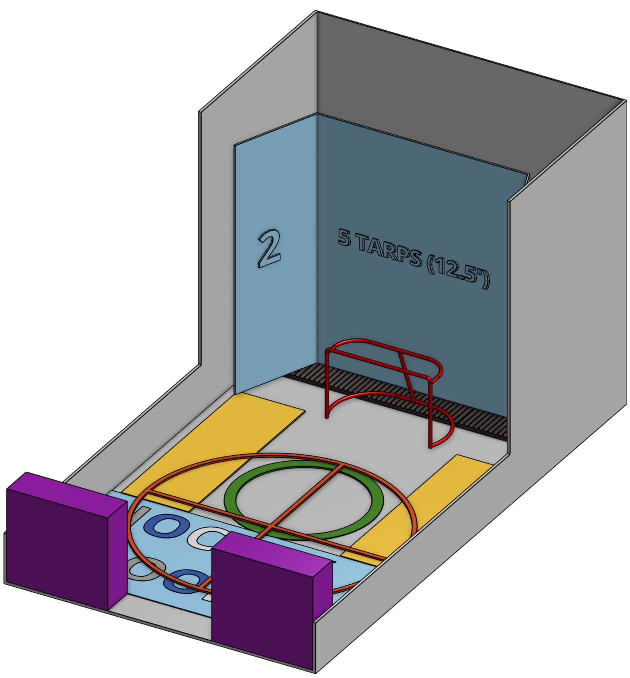
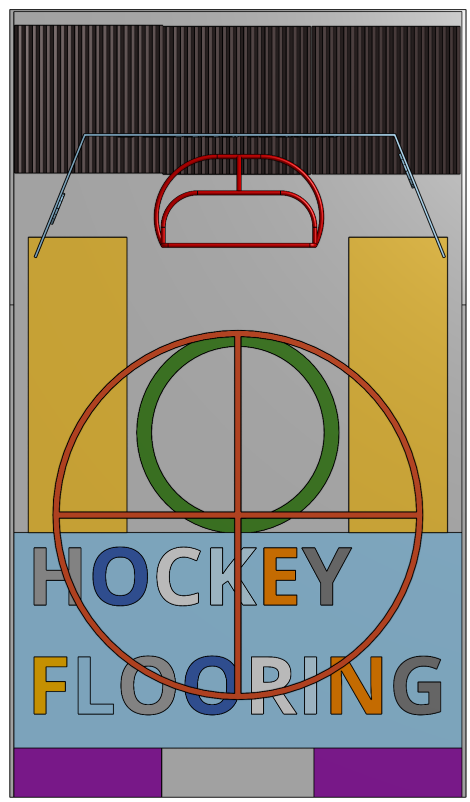
July 23, 2025





University of Alberta —— Department of Mechanical Engineering

Contents

Overview

This document validates dual-purpose designs for VVC's available space:

- Hockey shooting area
- Throwing venue (hammer, discus, shotput)

Sections detail space constraints, structural calculations, and safety-certified configurations.

NOTE: Designs A and B are complementary systems designed to function concurrently within the shared facility space.

1 Summary

The protection systems demonstrate significant safety margins under worst-case impact scenarios:

- **Tarp anchoring**: Supports 950 lb impact load with 3.6x safety factor
- **Beam performance**: 0.7" deflection under double the concentrated load (SF=3), negligible. *Refer to Appendix C for the calculated results.*

All designs meet structural requirements with recommended verifications.

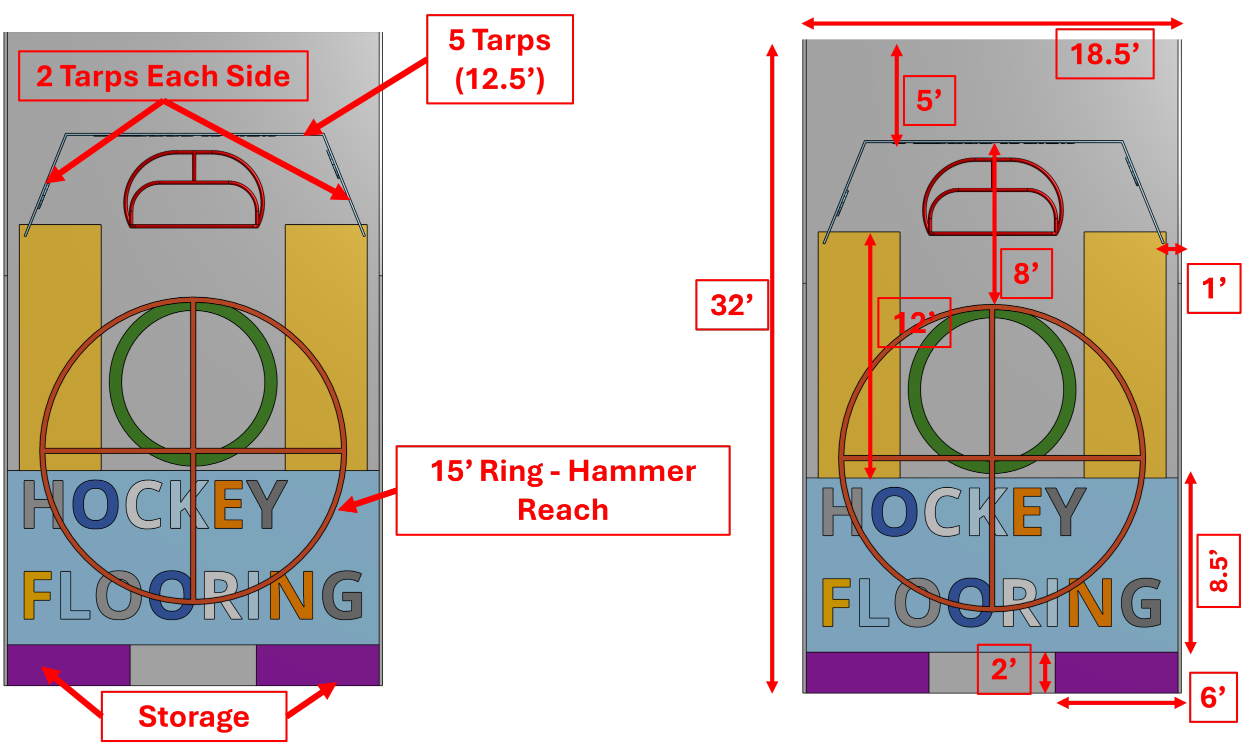


Figure 1: Top view of throwing space in the with high-level dimensioning.

2 Facility Dimensions and Requirements

- Squash court dimensions: 18.5 ft (W) × 32 ft (D) × 18.5 ft (H)
- Circle-to-tarp distance: 8 ft
- Tarp-to-wall clearance: 5 ft minimum

Parameter	Value	Unit
Anchor spacing	32	in
Minimum Chain Length	3	ft

Table 1: Key tarp hanging parameters

3 Design A: Throwing Circle and Javelin Runway

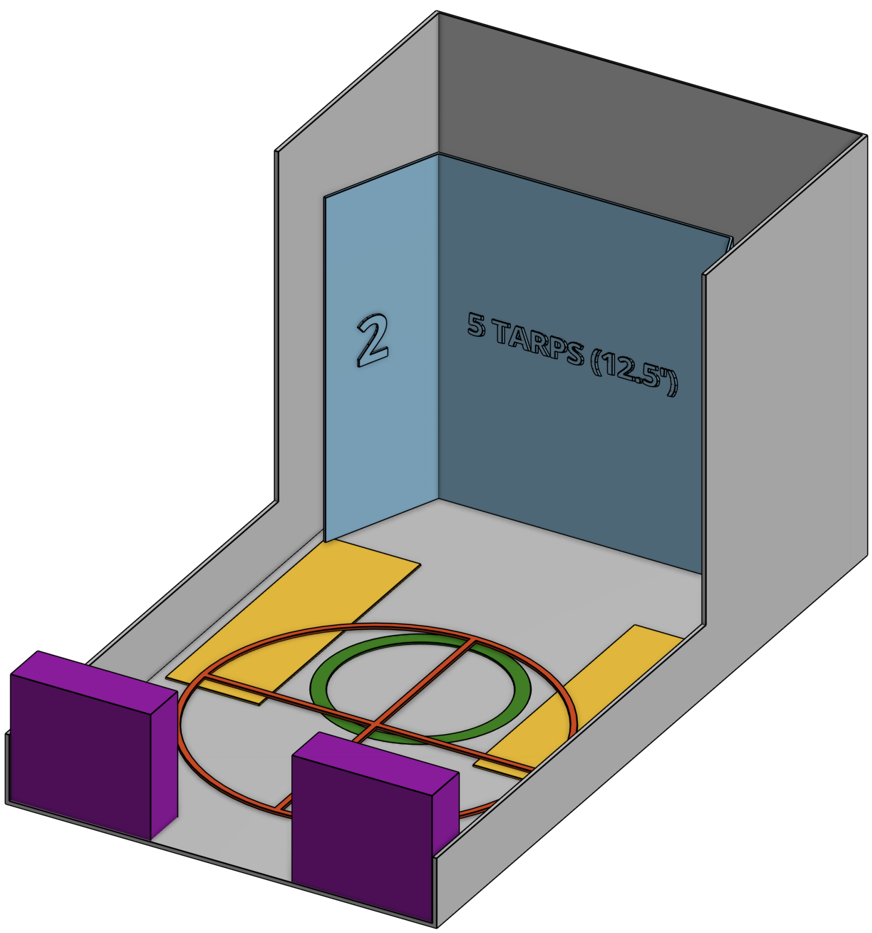


Figure 2: Isometric view of throwing area configuration

The throwing area features:

- **Embedded discus circle**: 2.5m diameter × 25mm depth
- **Interchangeable inserts**: Adaptable for hammer/discus diameters
- **Javelin runway**: 12' L × 4' W Mondo surface
- **Clearance margins**: Safe throwing radius with wall protection

This configuration meets all event requirements while maintaining safety buffers. The drawing below captures the schematic of the space in this configuration:

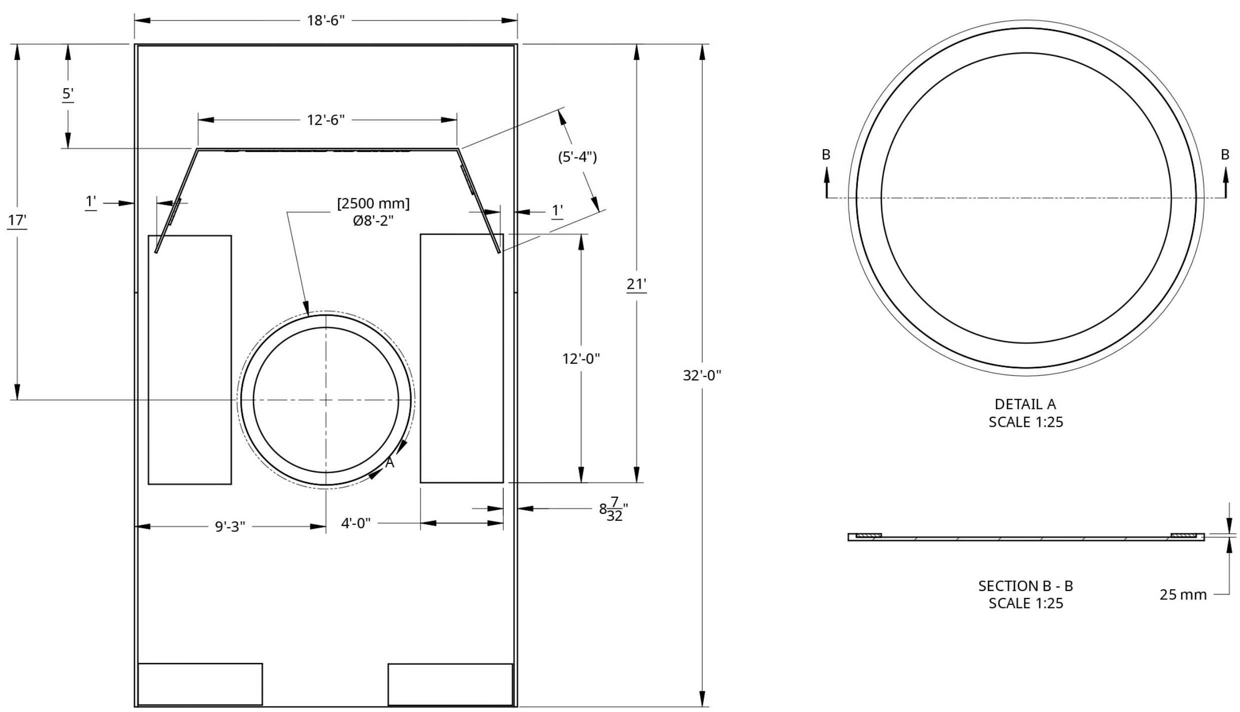


Figure 3: Engineering drawing of throwing configuration

The javelin runway is set to 12 feet to avoid overlapping the hockey flooring. Two runways, one on each side of the discus circle, are recommended to accommodate both left and right handed throwers.

4 Design B: Hockey Shooting Area

The hockey shooting flooring was designed to avoid overlapping with the discus circle or javelin runways. Accounting for the 2-foot-wide storage space, the hockey flooring spans 8.5 feet across the court's width.

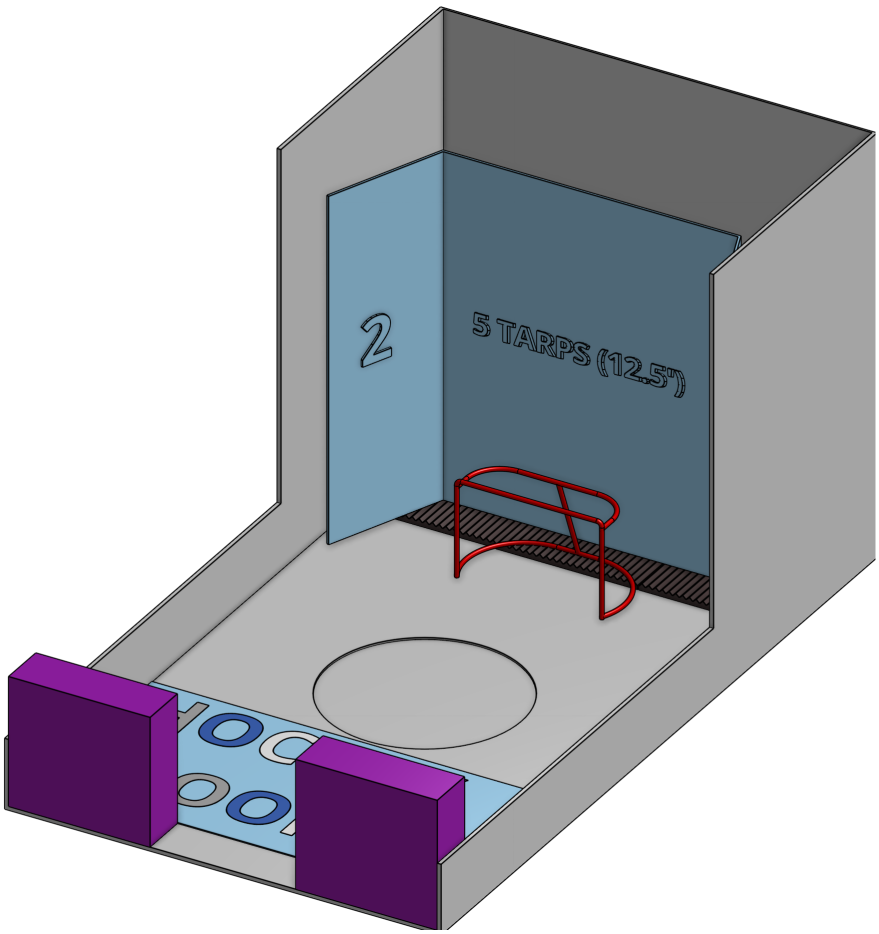


Figure 4: Hockey area configuration

Below is the high-level engineering drawing outlining the dimensions used for the hockey flooring. It is important that this layout is finalized only after the discus area has been fully specified, as the hockey flooring offers more flexibility and can be adjusted more easily to fit around the final field configuration.

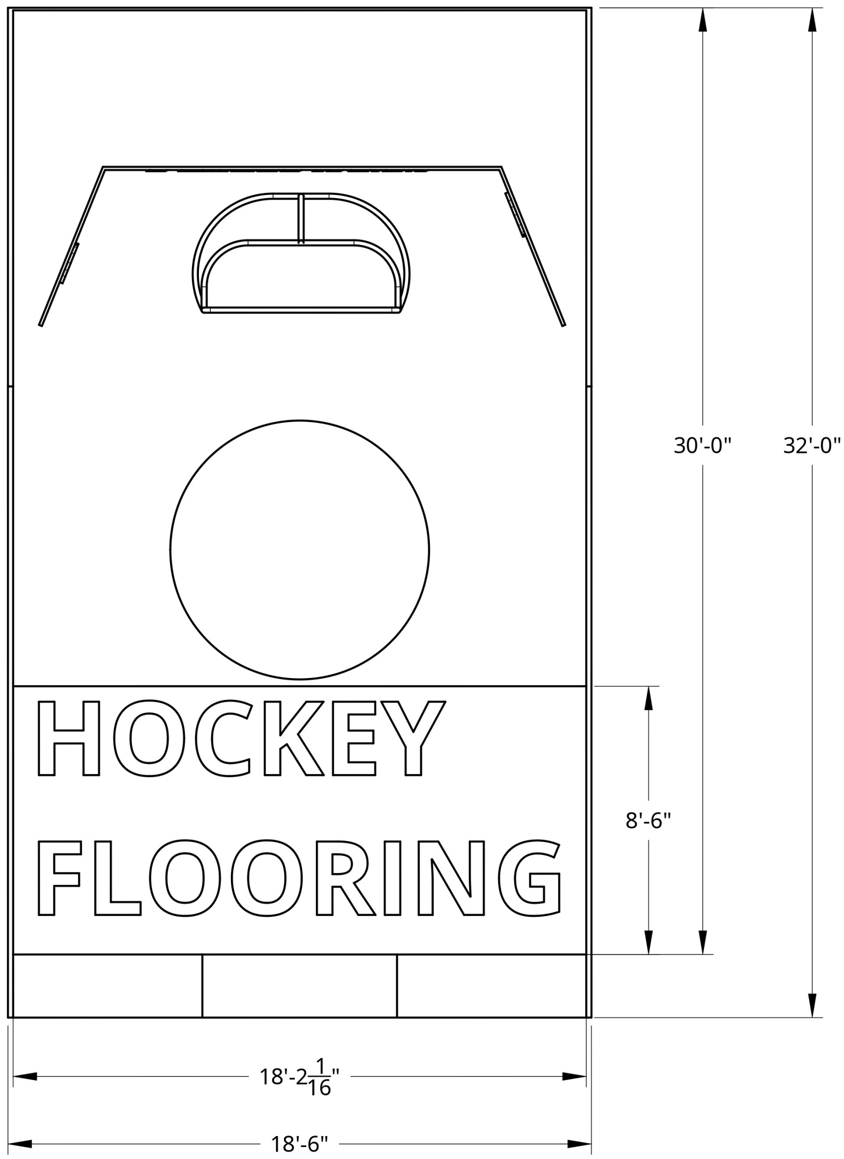


Figure 5: Hockey area configuration

5 Tarp Configuration and Load Estimation

Panel Specifications

The full panel specifications can be found in Appendix A.

- Dimensions: 36” W × 14.76’ H
- Weight: 19.35 kg/panel
- Total panels: 9

- Total static weight: 385 lb

Load Analysis

- Impact load: 550 lb (hammer throw) [1]
- Total design load: 950 lb

For safety, the hammer's impact force is assumed to act vertically on the tarp. Adding the static weight of the panels to the 550 lb impact load results in a total estimated design load of 950 lb.

6 Anchor Spacing and Lag Screw Performance

Design Parameters

- Number of anchors: 10
- Spacing: 28" centers
- Load per anchor: 95 lb
- Design load (2x SF): 190 lb

Lag Screw Specification

- 3/8" dia × 2.5" length hex head
- McMaster-Carr #95452A131
- Actual safety factor: 3.6

Parameter	Value	Unit
Design load	190	lb
Actual capacity	684	lb
Safety factor	3.6	-

Table 2: Lag screw performance

Refer to Appendix B for the full bolt connection calculations.

7 Structural Uncertainty and Recommendations

Key Uncertainty: Unknown ceiling load-bearing capacity.

[1] https://www.eeweb.com/physics-in-hammer-throw/

Recommendations

1. Site inspection by structural engineer
2. Verification of load-bearing members
3. Consider freestanding structure alternative

8 Conclusion

The proposed systems provide:

- Adequate protection for all throwing events
- Significant safety margins (SF $>$ 3)
- Hockey-compatible spatial configuration

Installation recommended with structural verification.

A Appendix A: Tarp Information (for Weight Calculations)

EVELTARP THROWING TARP: PURCHASING & PLANNING INFORMATION

SELF-INSTALL TARP PANELS VS. CUSTOM INSTALLATIONS

We offer two types of sales of our tarps: Self-install and custom installations. Both are the same material and design. Due to the weight of the material our tarps are modular in design: a tarp is made up of individual 3’ wide panels (32” effective width) that fix together using a sandwiched industrial hook and loop fastener system designed by us. Therefore, widths of our tarps are limitless; you can add or remove 3’ wide panels as needed. This enables you to increase the width later if necessary.

Self-Install 4.50m Modular Panels

These panels are sold through our partner, Rodhe Sport and can be purchased directly online at https://www.rodhesport.com/products/eveltarp-throwing-curtain

The panels are priced for the small college or private club / school on a limited budget. They are the exact same as our custom tarp system with the following differences:

1. The panels are at a fixed length: 4.50m (14’ 9”).
    a. With the hanging strap and D-Ring length is just over 15’).
2. No color option: sold only in black.
3. Purchaser is responsible for their own install, ensuring the structures being used are sound and can hold the weight of the tarp.
4. There is no installation charge.

Each panel provides 32” of effective width. To determine the tarp coverage, simply divide the width you want to cover in inches by 32” to get the number of panels you need. For instance, if you have 20’ wide space to cover, you will need 7 - 8 panels to cover that space:

- 20 x 12” = 240”. 240” / 32” = 7.5, so you would go with either
- 7 panels (18.5’ width) or 8 panels (21.5’ width).

Custom Tarp Installations:

Our custom installation tarps are the same as our self-install option with the following differences:

1. Panel length (i.e. tarp height) is custom and practically limitless. However, heights beyond 9.00m may have longer delivery times.
2. We offer various colors for our custom installs. See color info below.

3. These installs offer a professionally engineered install if needed. We work with Sportsfield Specialties for our custom installs. Purchaser can self-install our custom length tarps however you are responsible for assuring the structures you are hanging from can sustain both static and dynamic loads.

COLORS

We offer our tarps in 2 standard colors: Black & White. Bespoke colors are available but may impact delivery times and in some cases, cost. Here are the colors we offer and some examples:




EvelTarp Colors

THE FABRIC & ITS ADVANTAGES

The EvelTarp is made of specialty webbing fabric that will withstand years of typical impact abuse (will withstand even relatively blunt, e.g. ‘tailwind’ javelins). Unlike netting-like materials, hammer handles and TAPED wires will not catch in this fabric thus you can throw regular outdoor hammers into our tarps. These will withstand the abuse that conveyor belting will take but at a fraction of the weight and offer a continuous surface. They are the perfect balance between manageability and weight: simple to hang and store yet heavier than netting or other fabrics and therefore will absorb the impact of heavy implements much more readily with less movement, thus conserving space and providing a far less chance that an implement will swing back toward an athlete.

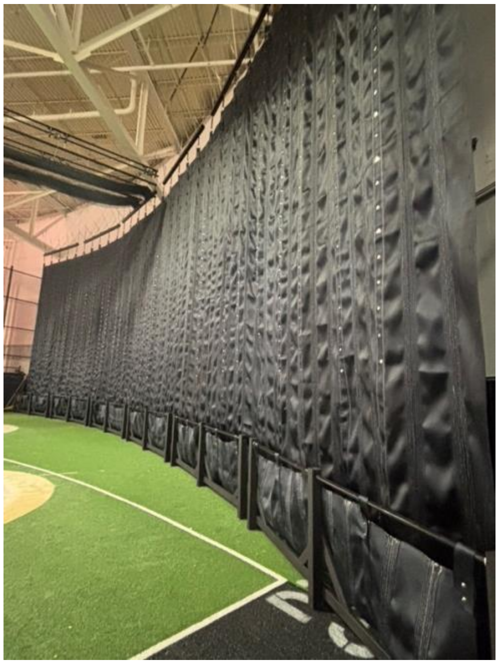
4.50m Panel

ADAPTABLE

Each tarp comes standard with top loops and 'D' rings from which the tarp is hung. While these tarps are designed to withstand years of normal daily use, bottom loops are available as an add-on in case it becomes necessary to reverse the hang & minimize "hot zone" usage. Bottom loops can also be used to pull back the tarp's bottom in order to create an angled orientation of the tarp to the thrower if a low ceiling setup is required. The bottom loops can also be used to anchor the tarp bottom if needed.

D-Ring Panel Attachment

Currently in development, we will also be offering a 'trough' implement catching system for those that need to protect their floors from falling implements (and vice-versa).



Havard 'Tarzilla' with Trough System

As our tarps are made from individual panels that can be added or subtracted as needed, they are highly versatile.

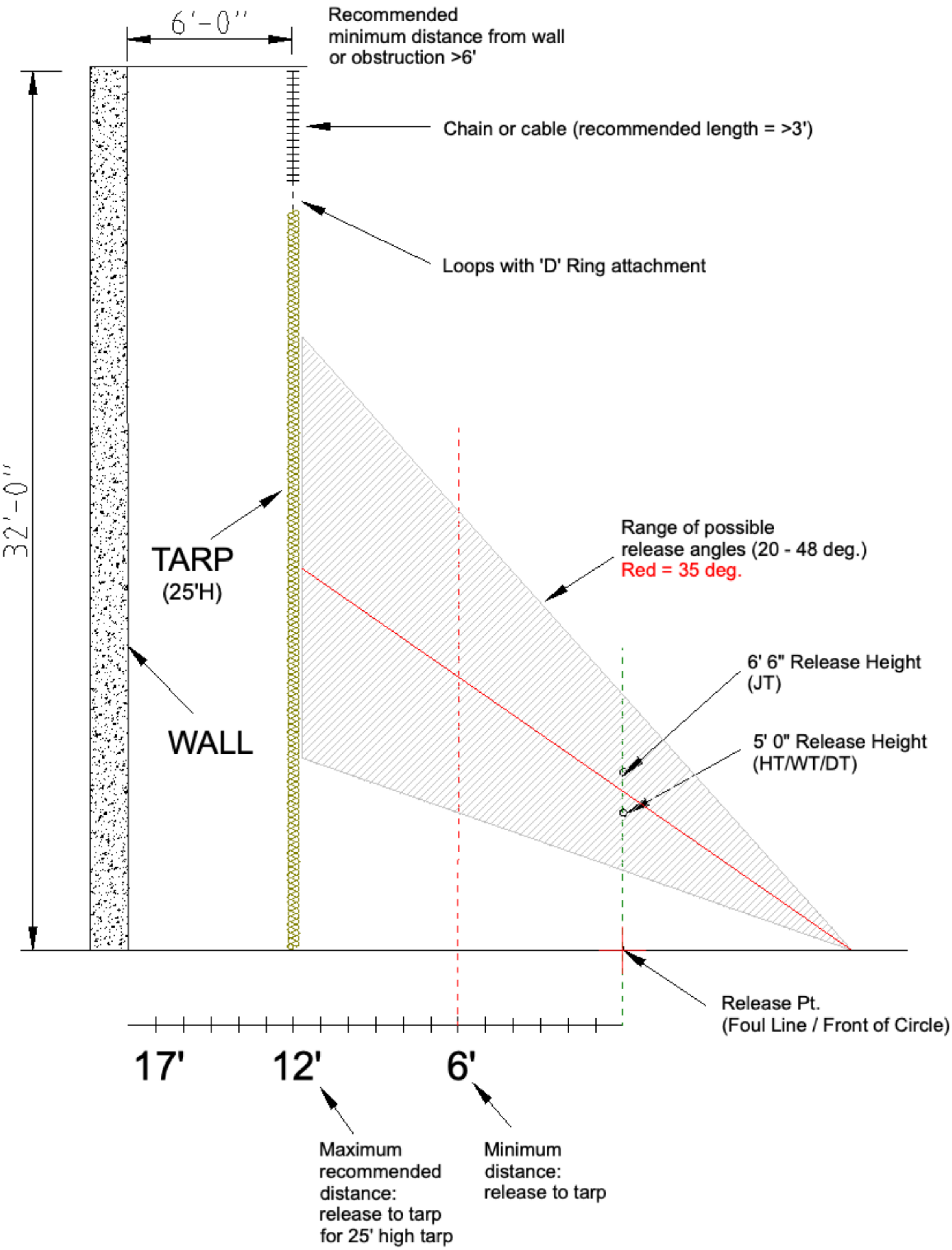
INSTALLATION

Each tarp is hung via 110mm (4.3”) wide ‘D’ rings woven into 100mm (4.0”) loops of web fabric attached to panel tops. The tarp is then suspended via chain or wire rope/cable from your existing ceiling structure. This is necessary if throwing hammer and / or weight into the tarp. If only shot or discus are being thrown into the tarp then the D-rings can be directly connected to the ceiling structure.

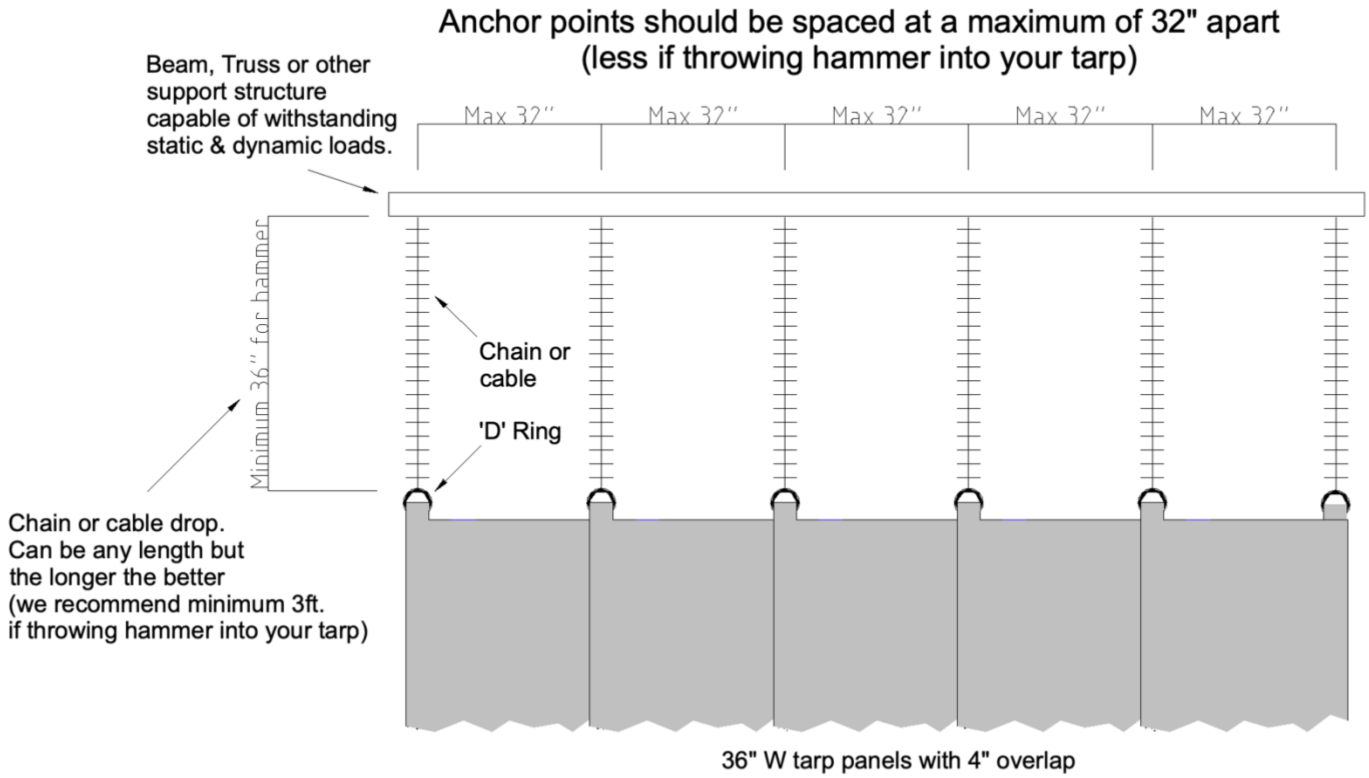
Tarps can be either assembled on the ground and then hung as a single unit (with proper lift equipment) or panels can be hung individually and fastened together one at a time while hung. Consult with Derek regarding the number of anchor points and chain drops required and the best way to hang your tarp.

The higher the tarp the less space needed behind the tarp for absorption. For SP and DT 36” is needed with a typical tarp. For hammer and weight throw, a minimum of 6’ (84”) clearance is required behind the tarp. Below is a schematic to give you an idea of the heights needed for various release distances.

NOTE: It is the buyer’s responsibility to ensure that the structures from which the tarp will be hung can withstand both the static and dynamic loads that are associated with the tarp and associated activities. It is also the buyer’s responsibility to ensure that the tarp is hung in a safe and appropriate manner.


6'-0"
Recommended minimum distance from wall or obstruction >6'
Chain or cable (recommended length = >3')
Loops with 'D' Ring attachment
32'-0"
TARP
(25'H)
WALL
Range of possible release angles (20 - 48 deg.)
Red = 35 deg.
6' 6" Release Height (JT)
5' 0" Release Height (HT/WT/DT)
Release Pt. (Foul Line / Front of Circle)
17'
12'
6'
Maximum recommended distance: release to tarp for 25' high tarp
Minimum distance: release to tarp

Planning for your tarp:



PURCHASE

Contact Derek for pricing on custom install tarps (contact below). Hardware for hanging is the responsibility of the buyer (see below re: assistance from us).

Self-install tarps are sold through https://www.rodhesport.com/products/eveltarp-throwing-curtain and typically deliver in less than a week. Panels are $810.00USD.

Prices do not include freight delivery or tax where applicable. Prices ***do include*** input and help with design, advice on install, etc.

Custom length tarps typically require an 8-10 week lead in period before delivery, however we carry some standard lengths and colors in stock (contact Derek). Bespoke colors may take longer.

To order or for more information please contact Derek at eveltrak@me.com or 312-998-3001.

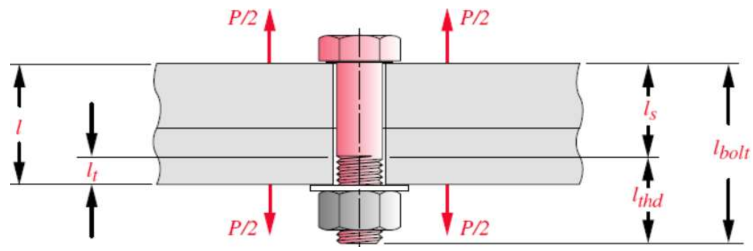
SPECIFICATIONS:

Height:	Standard heights (panel lengths) are 4.50m and < 9.00m. Longer panel lengths available upon request. Note: heights and overall square footage do not include loop length.
Width:	Each panel is 0.90m (36”) wide and provides a 0.80m (32”) effective width.
Attachment:	Panels connect via a sandwiched industrial hook & loop fastener system using a 0.10m (4”) flap. Attachments are reinforced with industrial fasteners.
Fabric	The panels are made from an industrial webbing fabric with a tensile strength of 9,800lbs./inch width.
Weight:	Panel weight is approximately 4.30kg per meter of length. A 4.50m H x 0.90m (36”)W panel weighs 19.35kg (42.6lbs.). For reference, a 21’W x 15H’ tarp will weigh approximately 350lbs.

B Appendix B: Bolt Calculations

Initial Inputs

$P_{tot} := 950 \cdot 2\ lbf$ **Total load on bolt(s)**



$N_{bolts} := 10$

$$P := \frac{P_{tot}}{N_{bolts}} = 190\ lbf$$

$\%_{preload} := 75\ \%$

Preload
– Static loading we assume for
- non permanent: $F_i = 0.75\ F_p$
- permanent: $F_i = 0.9\ F_p$

Dynamic and Cyclic loading
$\Rightarrow F_i > 0.75\ F_p$

$l_m := 1.75\ in$ Assumed length of material being compressed

$l_{bolt} := 2.5\ in$ Assumed length of the bolt

Material & Bolt Parameters

Choose between
"Steel" , "Alum", **and** "Iron"

$Material := \text{"Wood"}$

```
if Material = "Steel"
    v := 0.3
    E := 200 GPa
    A := 0.78715
    b := 0.62873
else
    if Material = "Wood"
        v := 0.034
        E := 10 GPa
        A := 0.79670
        b := 0.63816
    else
        if Material = "Iron"
            v := 0.211
            E := 100 GPa
            A := 0.77871
            b := 0.61616
```

Table 9-3: Stiffness parameters for equation 9.5

Material	ν	E (GPa)	E (Mpsi)	A	b
Steel	0.3	200	30.0	0.78715	0.62873
Aluminium	0.334	70	10.3	0.79670	0.63816
Gray Cast iron	0.211	100	14.7	0.77871	0.61616

Choose between
"Steel" , "Alum", **and** "Iron"

$Bolt\_Material := \text{"Steel"}$

```
if Bolt_Material = "Steel"
    v_bolt := 0.3
    E_bolt := 200 GPa
    A_bolt := 0.78715
    b_bolt := 0.62873
else
    if Bolt_Material = "Alum"
        v_bolt := 0.334
        E_bolt := 70 GPa
        A_bolt := 0.79670
        b_bolt := 0.63816
    else
        if Bolt_Material = "Iron"
            v_bolt := 0.211
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Steel	0.3	200	30.0	0.78715	0.62873
Aluminium	0.334	70	10.3	0.79670	0.63816
Gray Cast iron	0.211	100	14.7	0.77871	0.61616

Bolt Parameters

$d := \frac{3}{8}\ in$ **Change to correct diameter**

$A_t := 0.0775\ in^2$

Table 9-1: Principal dimensions of Unified National Standard screw threads.

		Coarse threads			Fine threads		
Size	Major Diameter d (in)	Threads per inch	Minor diameter dr (in)	Tensile stress area (in^2) A_t	Threads per inch	Minor diameter dr (in)	Tensile stress area (in^2)
0	0.0600	-	-	-	80	0.0438	0.0018

$$A_b := \frac{\pi \cdot d^2}{4} = 0.1104\ in^2$$

$Grade := 1$ **Change to correct grade**

$$l_{thd} := 2 \cdot d + 0.25\ in = 1\ in$$

$$l_s := l_{bolt} - l_{thd} = 1.5\ in$$

$$l_t := l_m - l_s = 0.25\ in$$

1	0.0730	64	0.0527	0.0026	72	0.0550	0.0028
2	0.0860	56	0.0628	0.0037	64	0.0657	0.0039
3	0.0990	48	0.0719	0.0049	56	00758	0.0052
4	0.1120	40	0.0795	0.0060	48	0.0489	0.0066
5	0.1250	40	0.0925	0.0080	44	0.0955	0.0083
6	0.1380	32	0.0974	0.0091	40	0.1055	0.0101
8	0.1640	32	0.1234	0.0140	36	0.1279	0.0147
10	0.1900	24	0.1359	0.0175	32	0.1494	0.0200
12	0.2160	24	0.1619	0.0242	28	0.1696	0.0258
¼	0.2500	20	0.1850	0.0318	28	0.2036	0.0364
5/16	0.3125	18	0.2403	0.0524	24	0.2584	0.0581
3/8	0.3750	16	0.2938	0.0775	24	0.3209	0.0878
7/16	0.4375	14	0.3447	0.1063	20	0.3725	0.1187
½	0.5000	13	0.4001	0.1419	20	0.4350	0.1600
9/16	0.5625	12	0.4542	0.1819	18	0.4903	0.2030
5/8	0.6250	11	0.5069	0.2260	18	0.5528	0.2560
¾	0.7500	10	0.6201	0.3345	16	0.6688	0.3730
7/8	0.8750	9	0.7307	0.4617	14	0.7822	0.5095
1	1.0000	8	0.8376	0.6057	12	0.8917	0.6630
1 1/8	1.1250	7	0.9394	0.7633	12	1.0167	0.8557
1 ¼	1.2500	7	1.0644	0.9691	12	1.1417	1.0729
1 3/8	1.3750	6	1.1585	1.1549	12	1.2667	1.3147
1 ½	1.5000	6	1.2835	1.4053	12	1.3917	1.5810
1 ¾	1.7500	5	1.4902	1.8995			
2	2.0000	4.5	1.7113	2.4982			
2 ¼	2.2500	4.5	1.9613	3.2477			
2 ½	2.5000	4	2.1752	3.9988			
2 ¾	2.7500	4	2.4252	4.9340			
3	3.0000	4	2.6752	5.9674			
3 ¼	3.2500	4	2.9252	7.0989			
3 ½	3.5000	4	3.1752	8.3286			
3 ¾	3.7500	4	3.4252	9.6565			
4	4.0000	4	3.6752	11.0826			

Grade Calculation

```
if Grade = 1
    S_p := 33 ksi
    S_y := 36 ksi
    S_ut := 60 ksi
else
    if (Grade = 2) ∧ (d < 0.875 in)
        S_p := 55 ksi
        S_y := 57 ksi
        S_ut := 74 ksi
    else
        if Grade = 2
            S_p := 33 ksi
            S_y := 36 ksi
            S_ut := 60 ksi
        else
            if Grade = 4
                S_p := 65 ksi
                S_y := 100 ksi
                S_ut := 115 ksi
            else
                if (Grade = 5) ∧ (d < 1.125 in)
                    S_p := 85 ksi
                    S_y := 92 ksi
                    S_ut := 120 ksi
                else
                    if Grade = 5
                        S_p := 74 ksi
                        S_y := 81 ksi
                        S_ut := 105 ksi
                    else
                        if Grade = 5.2
                            S_p := 85 ksi
                            S_y := 92 ksi
                            S_ut := 120 ksi
                        else
```

Grade #	Size range, outside diameter (in)	Minimum proof strength (kpsi)	Minimum S_y (kpsi)	Minimum S_{ut} (kpsi)	Material
1	0.25-1.5	33	36	60	Low or medium carbon
2	0.25-0.75	55	57	74	Low or medium carbon
2	0.875-1.5	33	36	60	Low or medium carbon
4	0.25-1.5	65	100	115	Medium carbon, cold drawn
5	0.25-1.0	85	92	120	Medium carbon, Q&T
5	1.125-1.5	74	81	105	Medium carbon,Q&T
5.2	0.25-1.0	85	92	120	Low-carbon martensite, Q&T
7	0.25-1.5	105	115	133	Medium-carbon alloy, Q&T
8	0.25-1.5	120	130	150	Medium-carbon alloy, Q&T
8.2	0.25-1.0	120	130	150	Low-carbon martensite, Q&T

Grade #	Size range, outside diameter (mm)	Minimum proof strength (MPa)	Minimum S_y (MPa)	Minimum S_{ut} (MPa)	Material
4.6	M5-M36	225	240	400	Low or medium carbon
4.8	M1.6-M16	310	340	420	Low or medium carbon
5.8	M5-M24	380	420	520	Low or medium carbon
8.8	M3-M36	600	660	830	Medium carbon, Q&T
9.8	M1.6-M16	650	720	900	Medium carbon, Q&T
10.9	M5-M36	830	940	1040	Low-carbon martensite, Q&T
12.9	M1.6-M36	970	1100	1220	Alloy, Q&T

```
if Grade = 7
    S_p := 105 ksi
    S_y := 115 ksi
    S_ut := 133 ksi
else
    if Grade = 8
        S_p := 120 ksi
        S_y := 130 ksi
        S_ut := 150 ksi
    else
        if Grade = 8.2
            S_p := 120 ksi
            S_y := 130 ksi
            S_ut := 150 ksi
        else
            if Grade = 4.6
                S_p := 225 MPa
                S_y := 240 MPa
                S_ut := 400 MPa
            else
                if Grade = 4.8
                    S_p := 310 MPa
                    S_y := 340 MPa
                    S_ut := 420 MPa
                else
                    if Grade = 5.8
                        S_p := 380 MPa
                        S_y := 420 MPa
                        S_ut := 520 MPa
                    else
                        if Grade = 8.8
                            S_p := 600 MPa
                            S_y := 660 MPa
                            S_ut := 830 MPa
                        else
                            if Grade = 9.8
                                S_p := 650 MPa
                                S_y := 720 MPa
                                S_ut := 900 MPa
                            else
                                if Grade = 10.9
                                    S_p := 830 MPa
                                    S_y := 940 MPa
                                    S_ut := 1040 MPa
                                else
                                    if Grade = 12.9
                                        S_p := 970 MPa
                                        S_y := 1100 MPa
                                        S_ut := 1220 MPa
```

$S_p = 33.0000\ \text{ksi}$ $\quad S_p = 227.5270\ \text{MPa}$

$S_y = 36.0000\ \text{ksi}$ $\quad S_y = 248.2113\ \text{MPa}$

$S_{ut} = 60.0000\ \text{ksi}$ $\quad S_{ut} = 413.6854\ \text{MPa}$

$F_p := S_p \cdot A_t = 2557.5\ \text{lbf}$ $\quad F_i := F_p \cdot \%_{preload} = 1918.125\ \text{lbf}$

Spring Indexes

$b \cdot \left(\frac{d}{?} \right)$

$k_m := d \cdot E \cdot A \cdot \mathbf{e}^{\left(\cdots l_m\right)} = 4.9682 \cdot 10^{5}\ \frac{lbf}{in}$ Material Spring Index

$k_b := \frac{A_t \cdot A_b \cdot E_{bolt}}{A_t \cdot l_s + A_b \cdot l_t} = 1.7259 \cdot 10^{6}\ \frac{lbf}{in}$ Bolt Spring Index

Static Loading

$C := \frac{k_b}{k_m + k_b} = 0.7765$

$F_b := F_i + C \cdot P = 2065.657\ lbf$ Load in Bolt

$F_m := F_i - (1 - C) \cdot P = 1875.657\ lbf$ Load in Material

```
if  F_m < 0                        = "Good"
  "Connection has failed"
else
  "Good"
```

Joint Seperation Factor

$P_b := C \cdot P = 147.532\ lbf$ Portion of load P in bolt

$P_m := (1 - C) \cdot P = 42.468\ lbf$ Portion in material

$P_0 := \frac{F_i}{1 - C} = 8581.5994\ lbf$ Load required to seperate a joint

Cyclic Loading In Bolt

$F_{mean} := \frac{F_b + F_i}{2} = 1991.891\ lbf$

$F_{alt} := \frac{F_b - F_i}{2} = 73.766\ lbf$

```
if  %_preload ≠ 0
  K_fm := 1
```

$K_f := 3$

Brinell Hardness	SAE Grade (UNS)	Metric Class (ISO)	K_f Rolled threads	K_f Cut threads	K_f Fillets
< 200 (annealed)	≤ 2	≤ 5.8	2.2	2.8	2.1
> 200 (hardened)	≥ 4	≥ 6.6	3.0	3.8	2.3

$\sigma_m := K_{fm} \cdot \frac{F_{mean}}{A_t} = 25.7018\ ksi$ Mean Stress

$\sigma_a := K_f \cdot \frac{F_{alt}}{A_t} = 2.8555\ ksi$ Alternative Stress

$\sigma_i := K_{fm} \cdot \frac{F_i}{A_t} = 24.75\ ksi$ Initial pre-load stress

$\sigma_b := \frac{F_b}{A_t} = 26.6536\ ksi$ Axial Stress

Endurance Strength of Bolt

```
if  S_ut < 1463 MPa
```

$S'_e := 0.504 \cdot S_{ut}$

else

$S'_e := 737\ \text{MPa}$

$S'_e = 30.24\ \text{ksi}$

$a := 1.58$

$b := -0.085$

$k_a := a \cdot \left(\frac{S_{ut}}{\text{MPa}}\right)^b = 0.9468$

	MPa		kpsi	
Surface finish	**a**	**b**	**a**	**B**
Ground (standard unless otherwise indicated)	*1.58*	*-0.085*	*1.34*	*-0.085*
Machined or Cold drawn	4.51	-0.265	2.7	-0.265
Hot-rolled	57.7	-0.718	14.4	-0.718
As-forged	272	-0.995	39.9	-0.995

$k_b := 1$

$k_c := 0.85$

$$k_c = \begin{cases} 1 & \text{Bending} \\ 0.85 & \text{Axial} \\ 0.59 & \text{Pure torsion} \end{cases}$$

In the case of combined loading, bending is dominant $k_c = 1$

*If there is also alternating axial stress, the **alternating axial** stress component must be divided by $k_{caxial} = 0.85$*

$T_F := 150$ temperature must be in farenheit if using formula

$k_d := 0.975 + 0.432 \cdot \left(10^{-3}\right) \cdot T_F - 0.115 \cdot \left(10^{-5}\right) \cdot T_F^{\,2} + 0.104 \cdot \left(10^{-8}\right) \cdot T_F^{\,3} - 0.595 \cdot \left(10^{-12}\right) \cdot T_F^{\,4} = 1.0171$

$k_d := 1$

•Base reliability 50%

$k_e := 0.814$

Reliability	Ke
50	1
90	0.897
95	0.868
99	0.814
99.9	0.753
99.99	0.702
99.999	0.659
99.9999	0.62

$k_f := 1$ Assume =1 unless otherwise indicated

$S_e := k_a \cdot k_b \cdot k_c \cdot k_d \cdot k_e \cdot k_f \cdot S'_e = 19.8091\ \text{ksi}$

Safety Factor - Bolt

$n_f := \frac{S_e \cdot \left(S_{ut} - \sigma_i\right)}{S_e \cdot \left(\sigma_m - \sigma_i\right) + S_{ut} \cdot \sigma_a} = 3.6716$

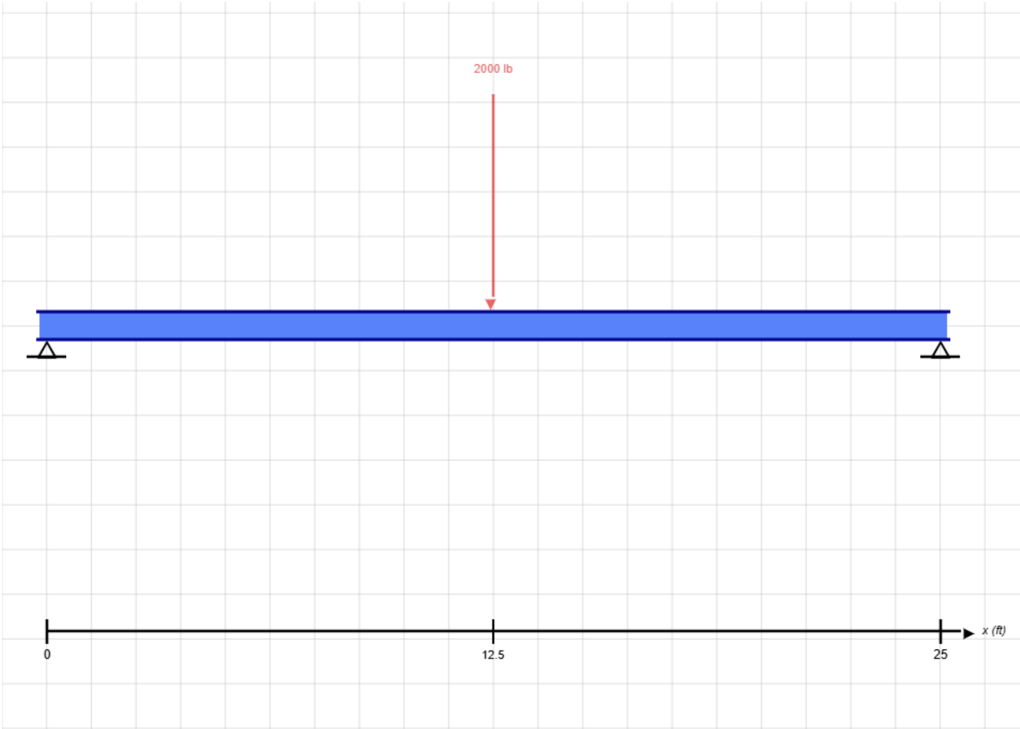
$n_y := \frac{S_y}{\sigma_b} = 1.3507$

$n_{sep} := \frac{P_0}{P} = 45.1663$

C Appendix C: Beam Calculations (for Structural Integrity)

SKYCIV BEAM ANALYSIS REPORT

Load Combination: 1 - Load Combination 1



Software: SkyCiv Beam v3.3.1
Sat Jun 28 2025 01:00:54 GMT-0600 (Mountain Daylight Time)

Project Info

Engineer: Wesley Eze (weze@ualberta.ca)

Included in this Report:

INPUT SUMMARY

General Info

Beam Length:	25 ft
Section Name:	8 x 5
Self Weight:	True

Supports

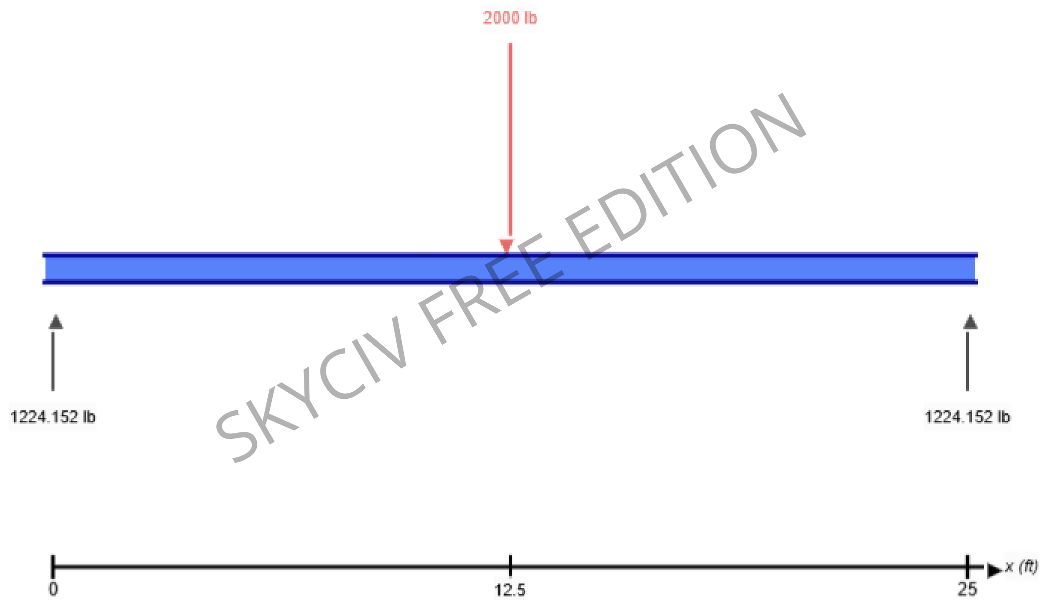
Support Type	Location
Pinned	0 ft
Pinned	25 ft

Loads

Load Type	Location	Magnitude	Load Case
Point Load	12.5 ft	-2000 lb	DL

undefined

FREE BODY DIAGRAM



RESULT SUMMARY

Check	Status	Limit	Ratio	Max
Deflection	PASS	L/250	0.595	L/420
Custom Stress Limit	FAIL	39 psi	280.65	10945.363 psi
Material Yield	PASS	36000 psi	0.304	10945.363 psi
Material Strength	PASS	58000 psi	0.189	10945.363 psi

ANALYSIS RESULTS

Reactions

Support at	R_x (lb)	R_y (lb)	Mx (lb-ft)
0	0	1224.152	0
25	0	1224.152	0

Force Extremes

Result	Max	Min
Bending Moment	13900.952 lb-ft	0 lb-ft
Shear	1224.152 lb	-1224.152 lb
Displacement Y	0 in	-0.713 in

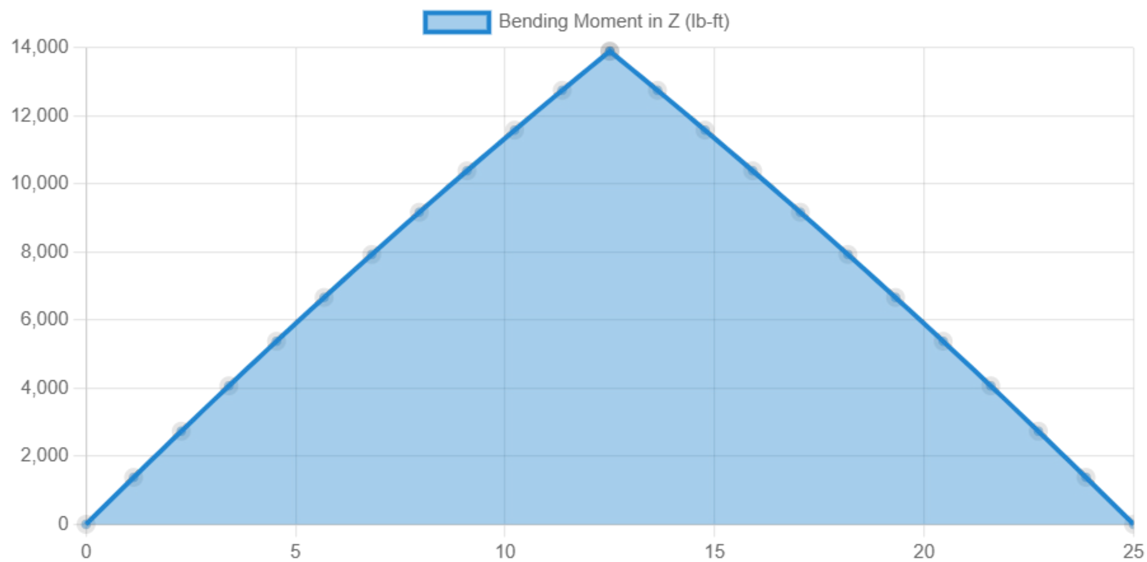
Stress Extremes

Upgrade to Unlock

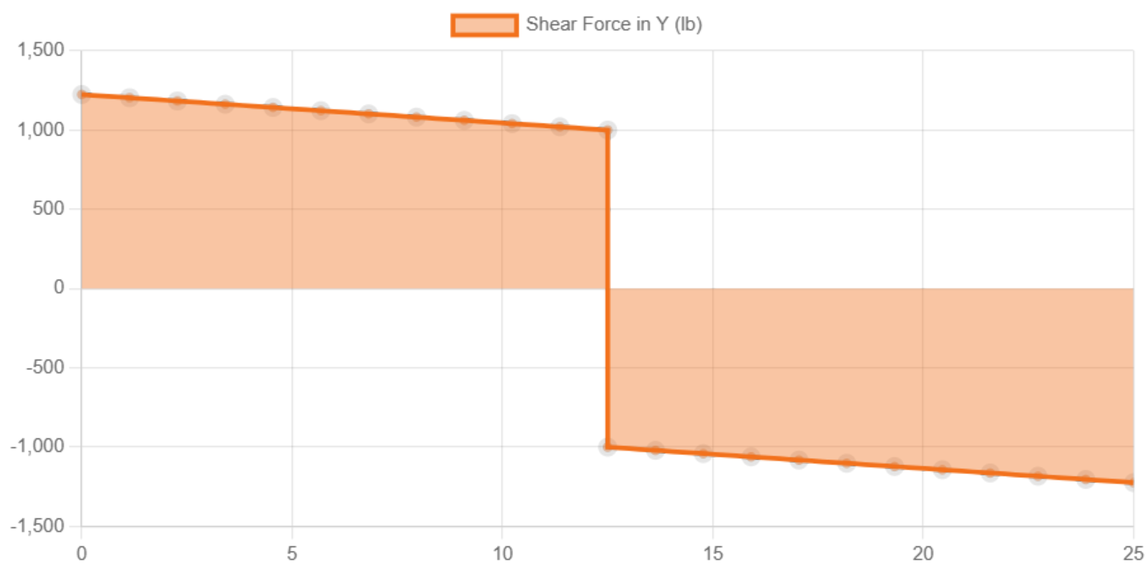
Result	Max	Min
Shear Stress Total	[illegible]	[illegible]
Max Combined Normal Stress	[illegible]	[illegible]
Min Combined Normal Stress	[illegible]	[illegible]
Axial Stress	[illegible]	[illegible]

DIAGRAMS

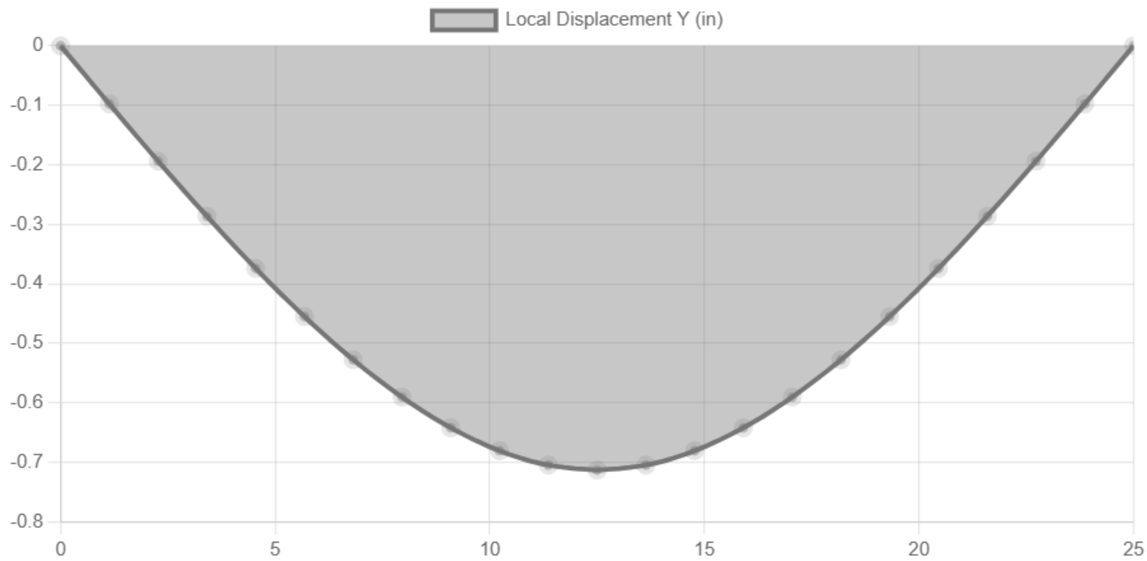
Bending Moment Diagram



Shear Force Diagram



Displacement



Location (ft)	0	12.5	25
Total Deflection (in)	0	0.713	0
Deflection/Span	-	L/420	-

The Deflection/Span results are calculated using the analysis results and the Deflection Limit of L/250 set in the **model settings.**